



GTAP 2021

Environmental Stressors Can Intensify the Impacts of Pandemics on Earth's Natural Resources and Global Food Systems

I. Haqiqi, D. S. Grogan,
M. Bahalou, T. W. Hertel,
J. Liu, U. L. C. Baldos



PURDUE UNIVERSITY
GLASS
Global to Local Analysis of Systems Sustainability



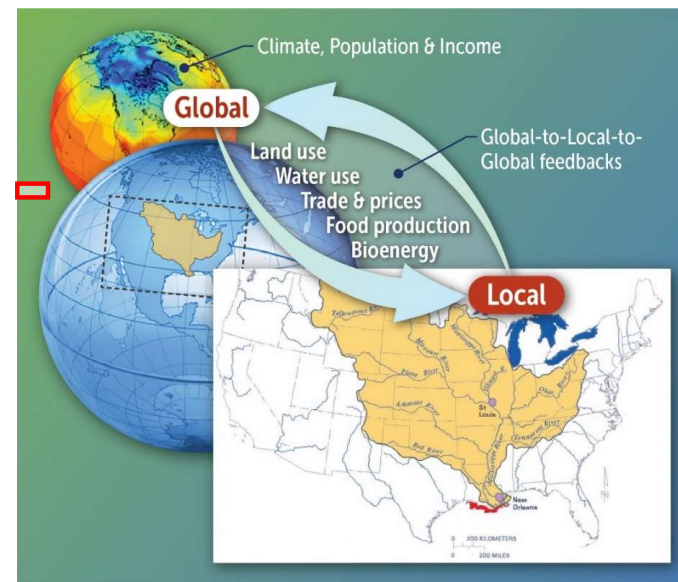
PCHES
Program on Coupled Human and Earth Systems



APPROACH:

Global-to-Local Analysis of Systems Sustainability

- Incorporates multidisciplinary perspectives
- Recognizes that Global Forces are often behind Sustainability Stresses
- Yet these Stresses are typically Highly Localized
- And Local responses to system stresses can have global consequences

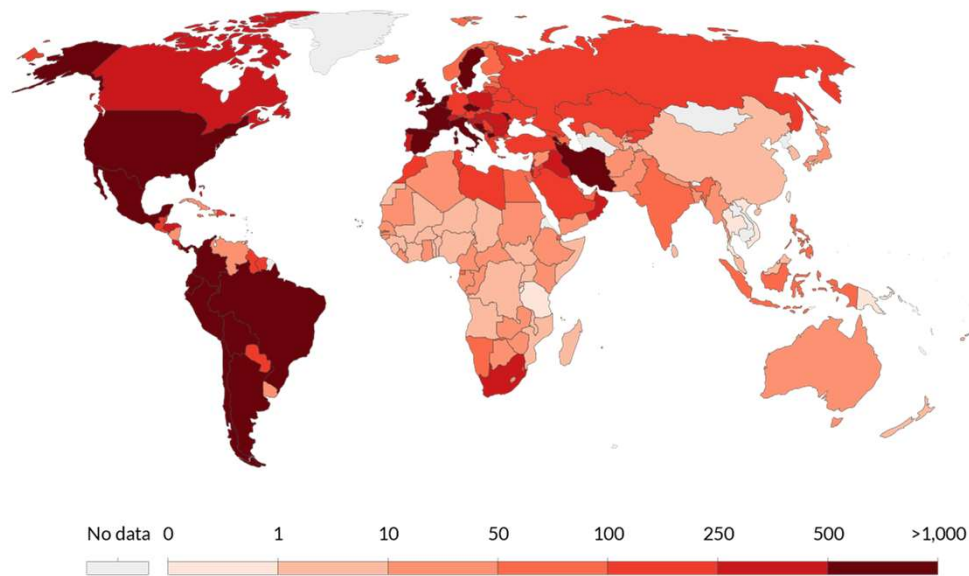


Global environmental stress

- **Resources are already under stress:** Annual groundwater withdrawal can be equivalent to more than 10 years of inflow to the groundwater systems.
- **Climate change is predicted to increase the stress**
- **Income and population growth are predicted to increase the stress**

Pandemic affects people and the food system

Cumulative confirmed COVID-19 deaths per million people, Nov 18, 2020
Limited testing and challenges in the attribution of the cause of death means that the number of confirmed deaths may not be an accurate count of the true number of deaths from COVID-19.

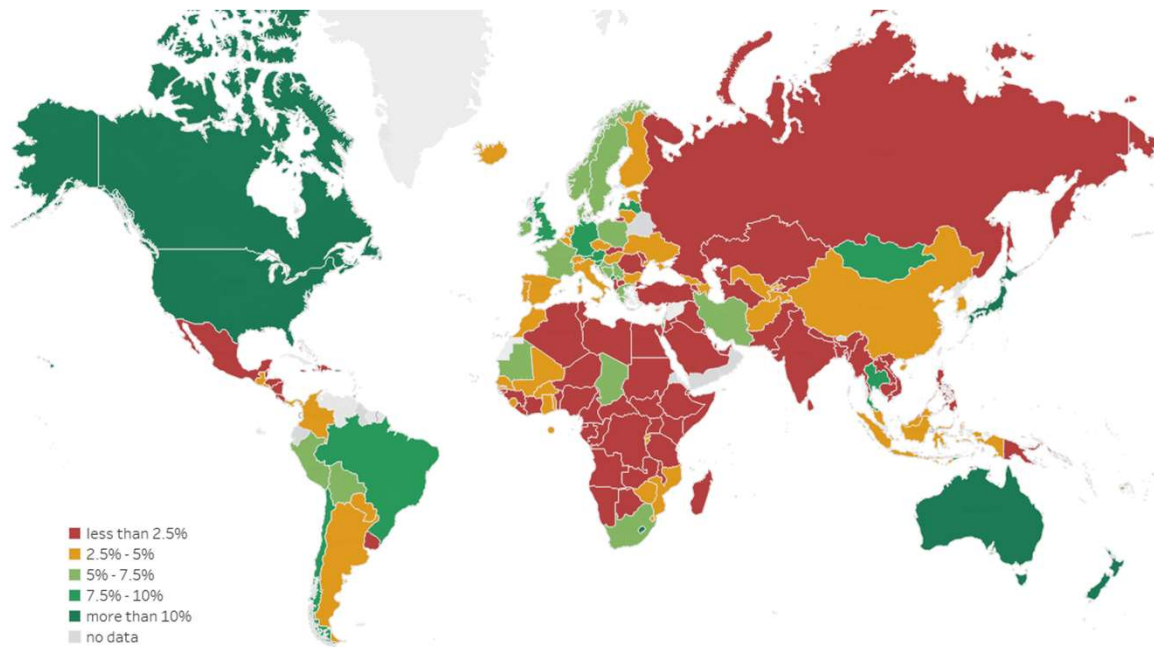


Source: European CDC – Situation Update Worldwide – Last updated 18 November, 13:05 (London time)

CC BY

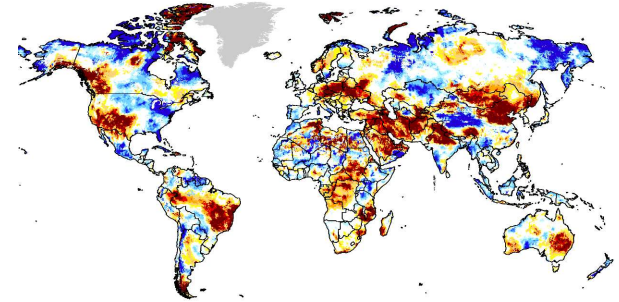
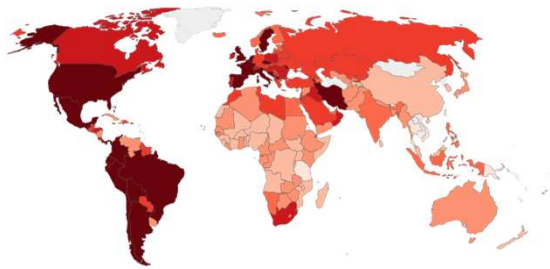
- People
 - Consumers of food
 - Workers in food industry
- Supply chain
 - Harvest and packaging costs
 - Transportation costs
 - Safety practices

Government responses to pandemics can moderate the damage



**Additional Spending and Forgone Revenue in Response to the
COVID-19 Pandemic (Percent of GDP)**

International Monetary Fund (IMF)



**What if
a pandemic
is combined with
a widespread
environmental stress?**

Known impacts:

scenarios	sustainability			food security	
	GHG	water	land	hunger	food prices
pandemic: income reduction 	✓	✓	✓	✗	✓
pandemic: increased costs 	✗	✗	✗	✗	✗
environment: heat stress 	✗	✗	✗	✗	✗
environment: water stress 	✗	✗	✗	✗	✗
pandemic + environmental stress	?	?	?	✗	?
(a) ?	✓	✓	✓	✗	✗
(b) ?	✗	✗	✗	✓	✓
(c) ?	✓	✓	✓	✓	✓

Unknown impacts?

Likely solutions?

- **GHG:** CO₂, N₂O, CH₄ emissions from food system
- **Water:** groundwater withdrawals
- **Land:** cropland area
- **Hunger:** population under minimum caloric requirement

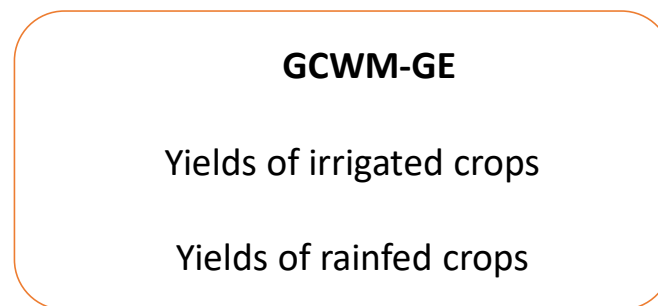
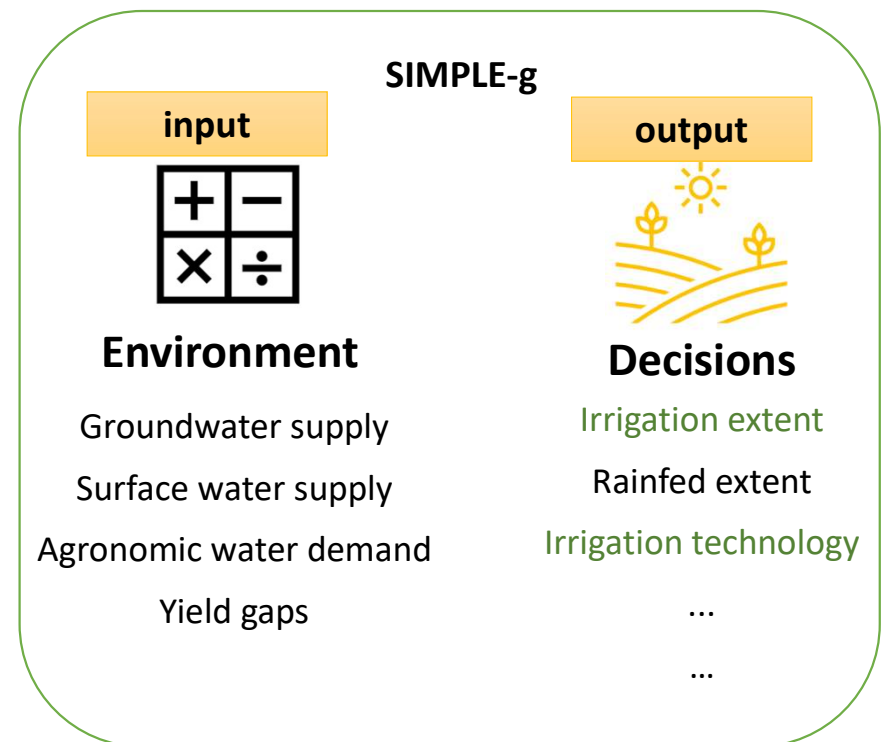
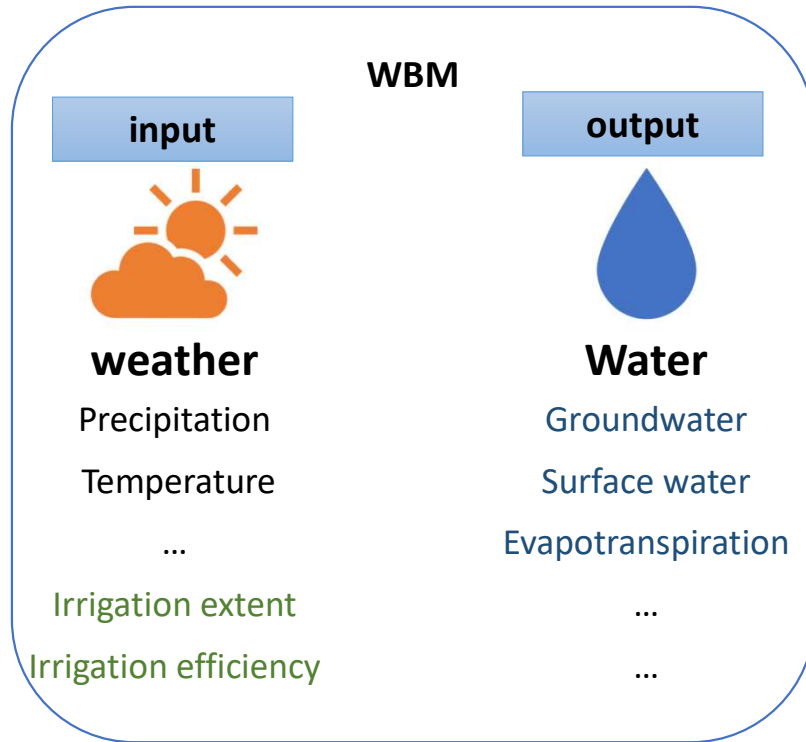
Key



improvement



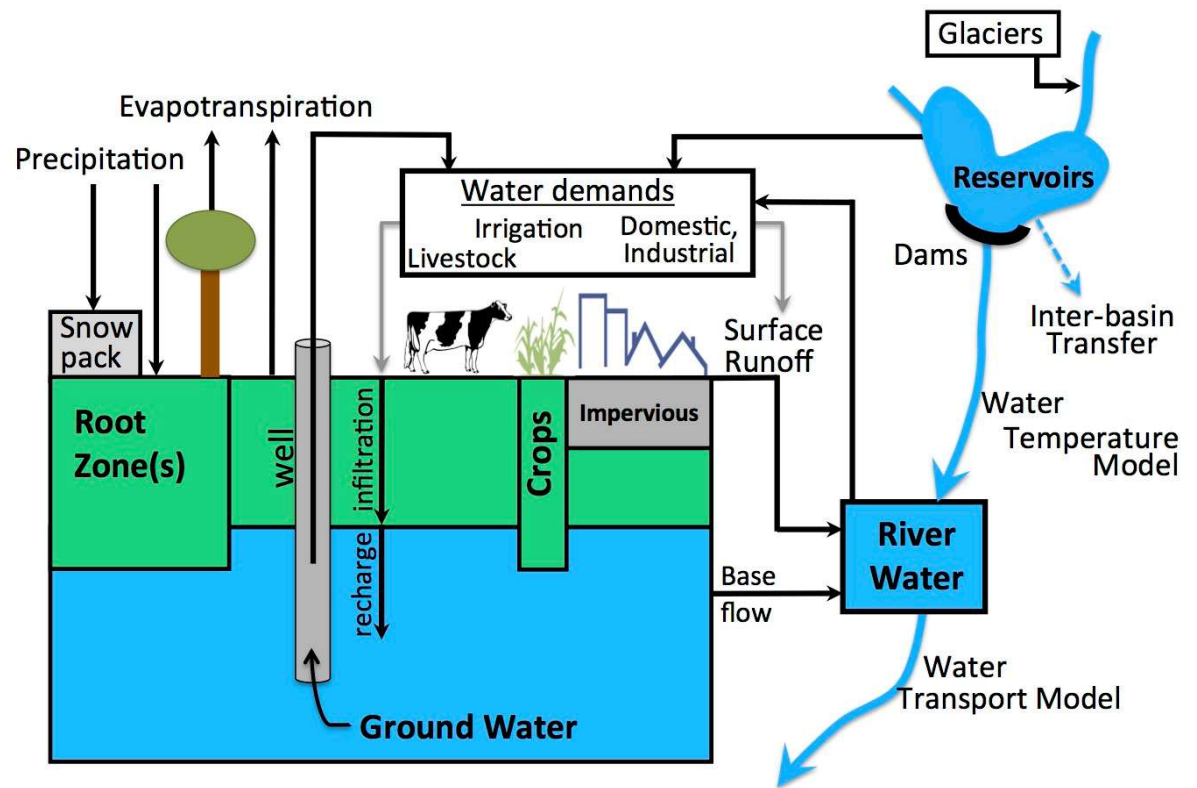
deterioration



WBM

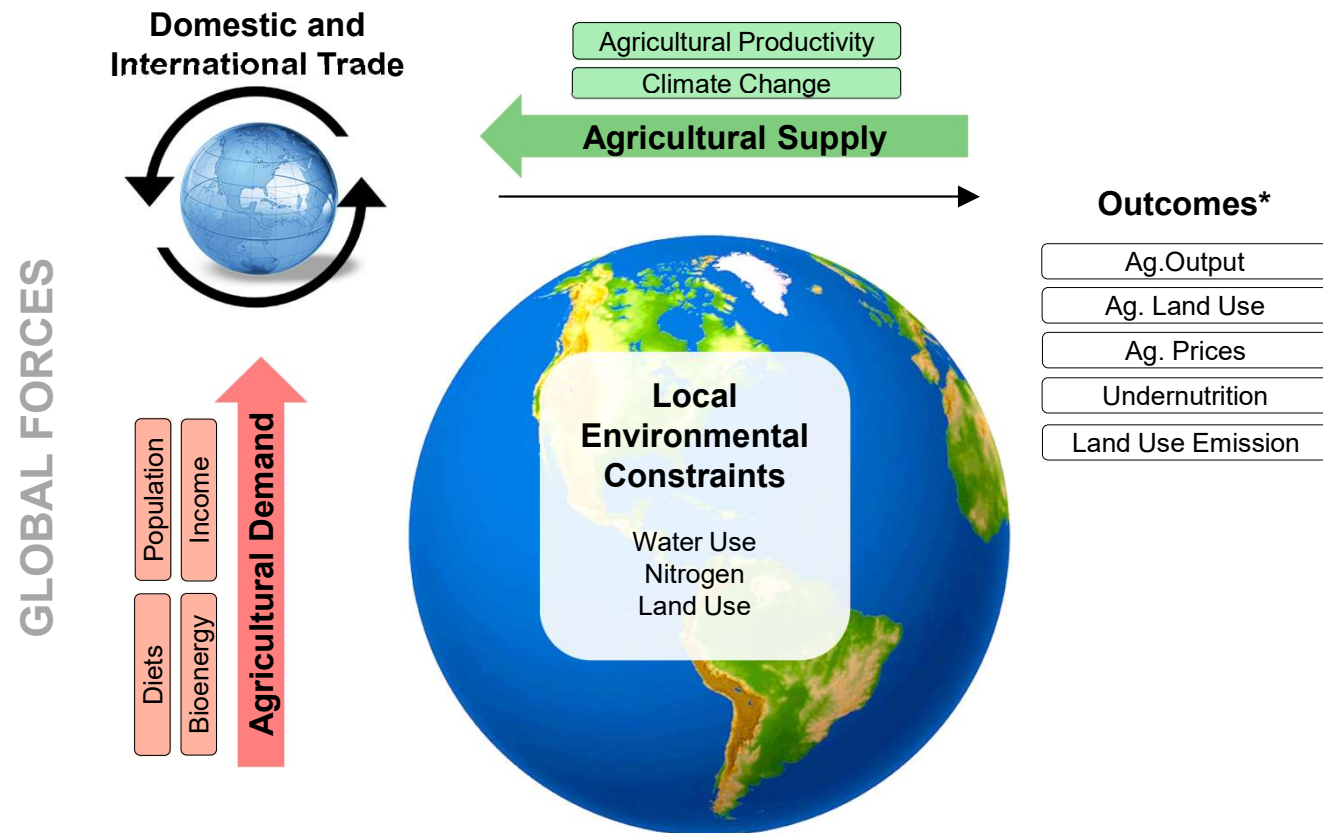
- The **Water Balance Model** was first developed at the University of New Hampshire, Durham, by Charles J. Vorosmarty in the 1990s.
- This study:
 - global 5 arc-min version.
- Grogan et al. 2017. The use and re-use of unsustainable groundwater for irrigation: a global budget. Environmental Research Letters 12, 034017

UNH Water Balance Model (WBM) Structure



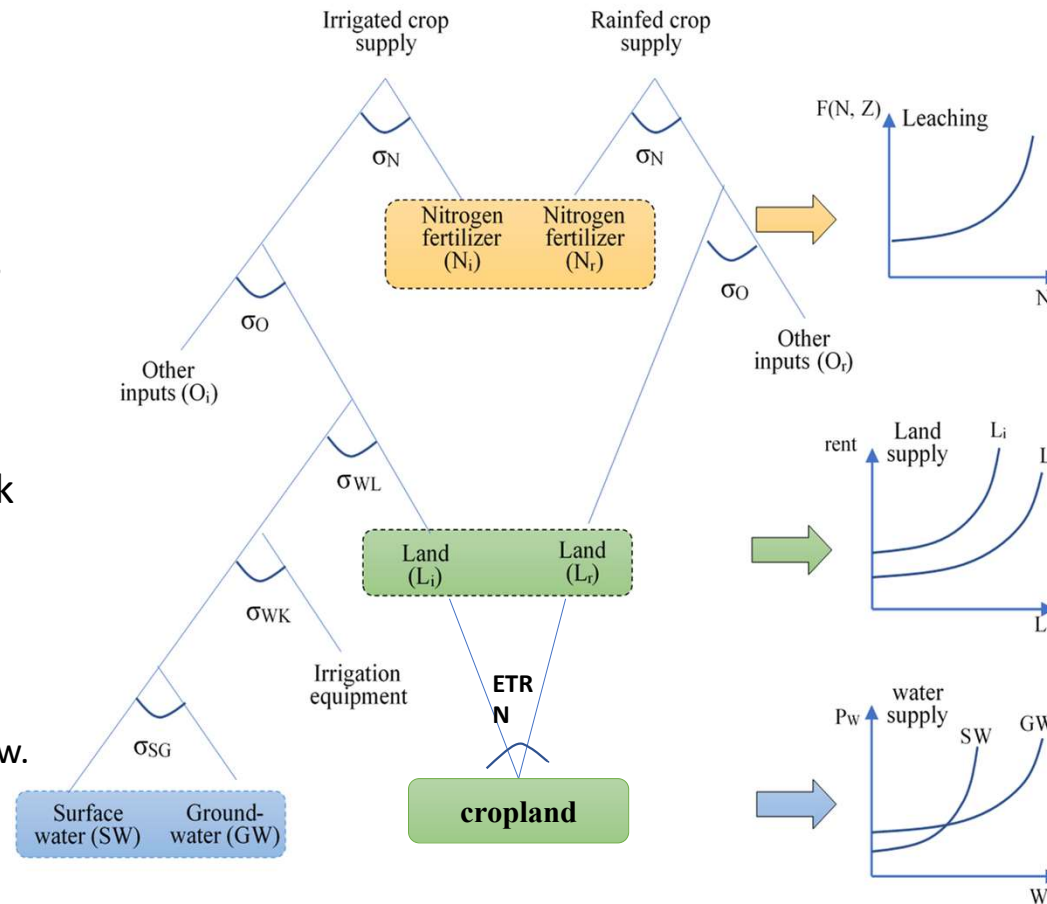
SIMPLE-G

- A global-to-local-to-global approach in the Food-Energy-Water systems
- Trade-off and synergies
 - Global food security goals
 - Local sustainability goals



SIMPLE-g

- **SIMPLE**: a Simplified International Model of agricultural Prices, Land use, and the Environment
- **SIMPLE-G**: A multiscale framework for integration of economic and biophysical determinants of sustainability
 - Baldos et al., 2020, Environ Model Softw.



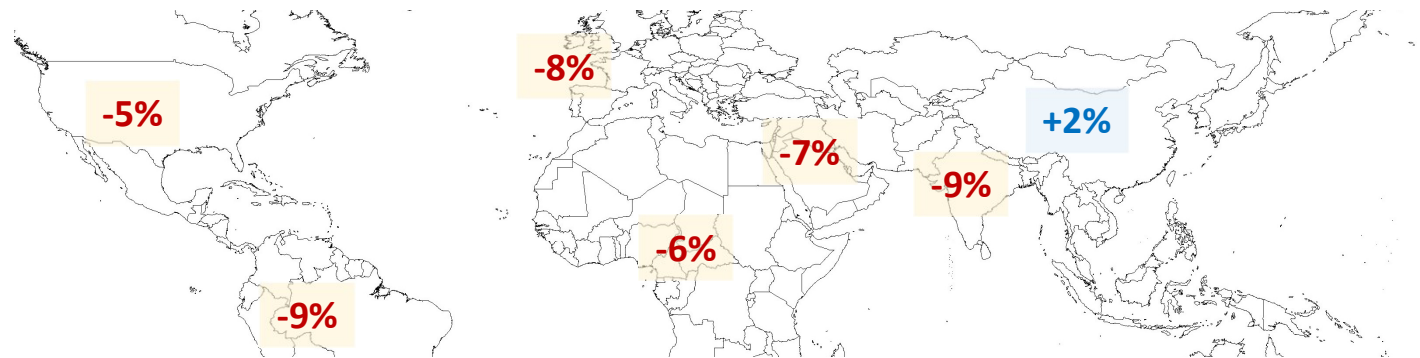
- National markets for crops and fertilizer

Grid-cell markets for land and water

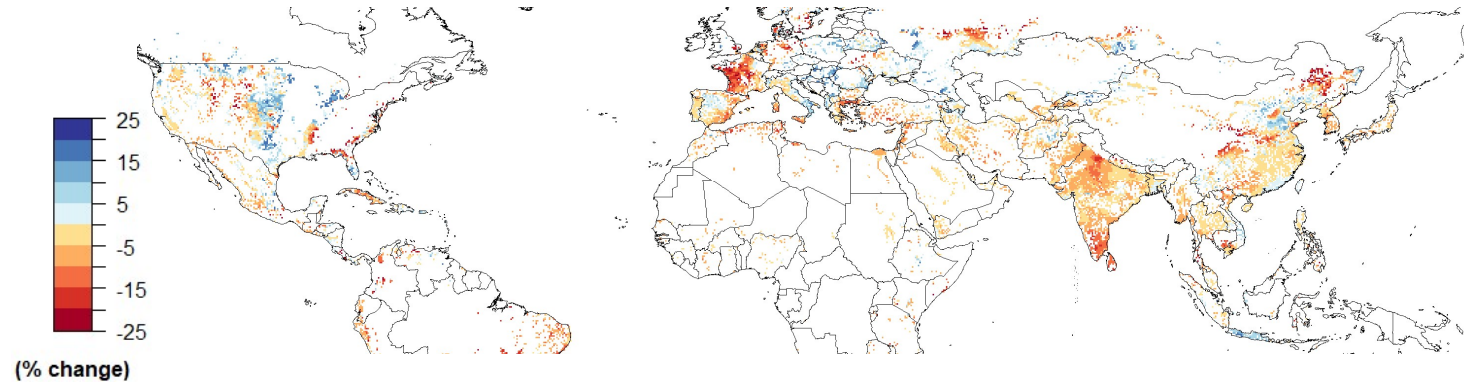
Gridded parameters

Scenarios:

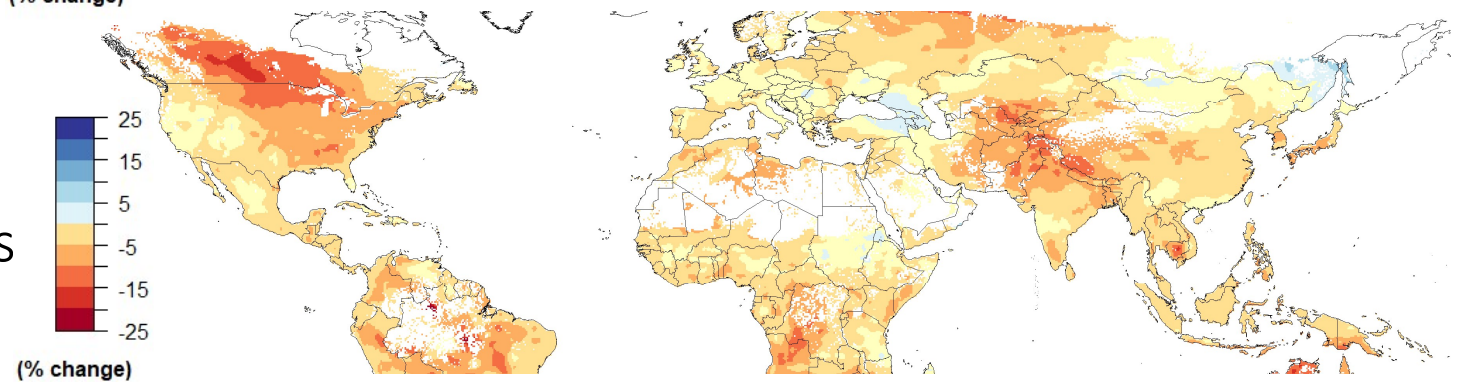
Income shocks:
% change in GDP



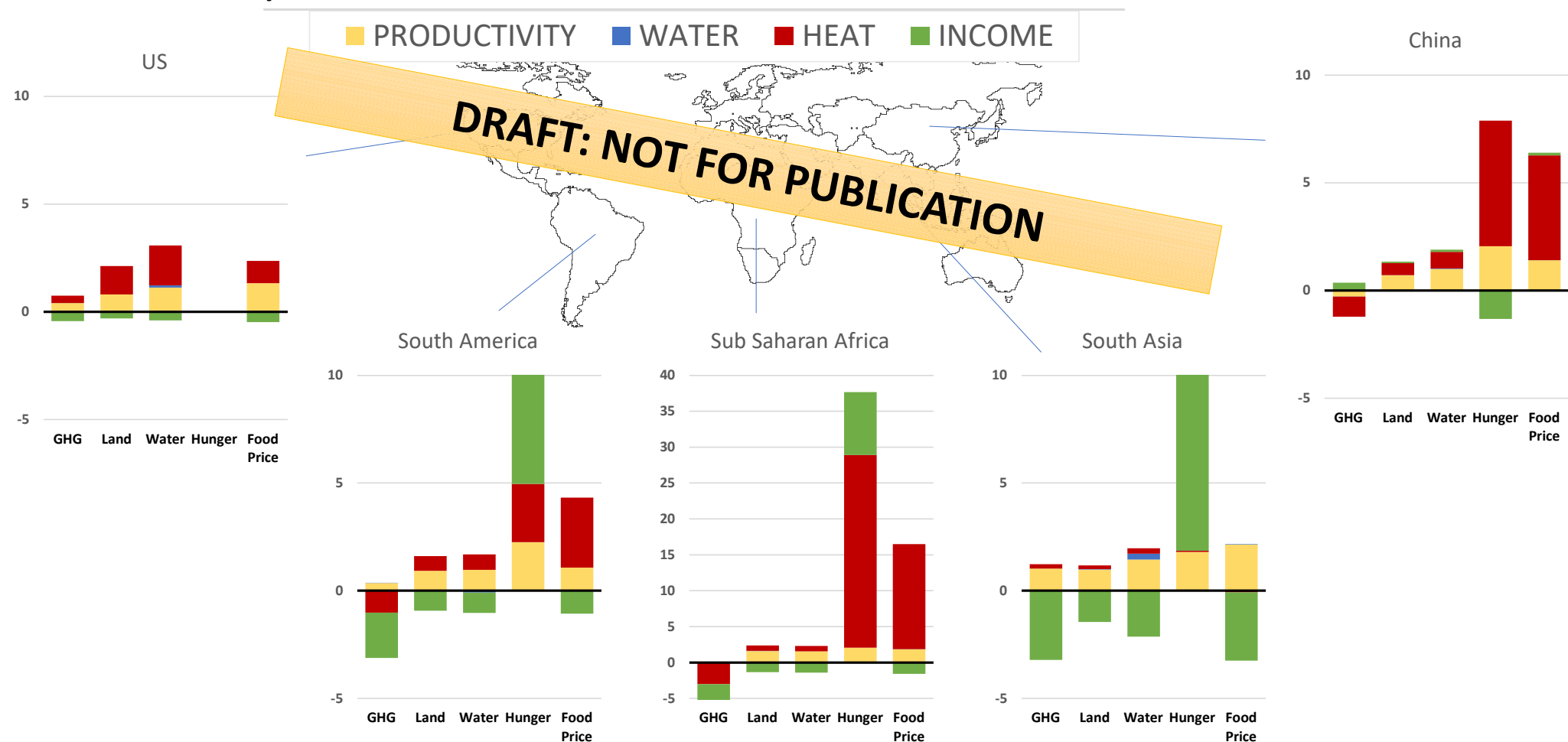
Water Stress:
% change in surface water available for irrigated agriculture



Heat Stress:
% change in crop yields for rainfed agriculture

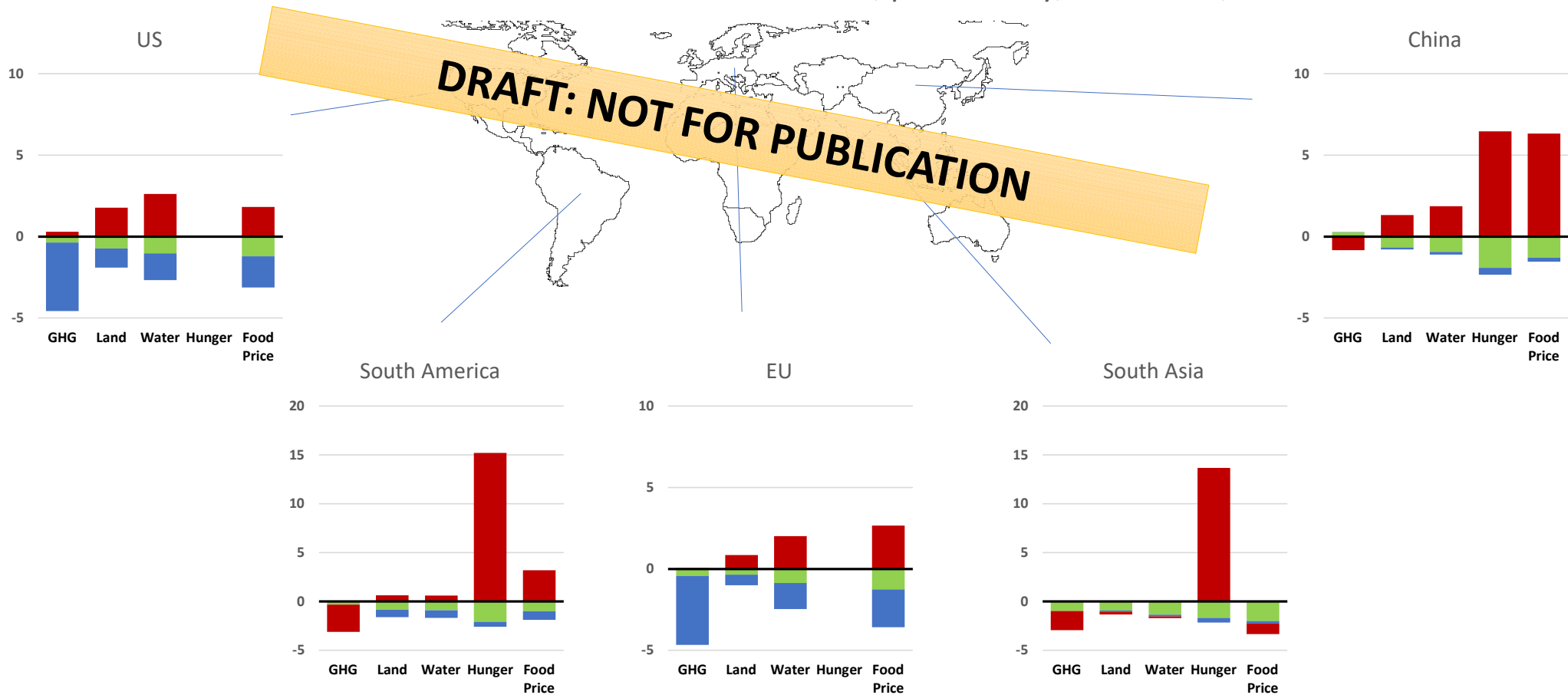


Results: global drivers of local sustainability stresses and food insecurity



Results: Impacts of pandemic + environmental stress + lower food loss and waste

■ Lower food loss ■ Lower food waste ■ Income shock, productivity, heat stress, water stress



Conclusions

- Pandemics
 - can reduce water use and land use
 - will increase hunger and malnutrition
- Environmental shocks:
 - can increase water and land stress
 - will increase hunger and malnutrition
- Compound pandemics and environmental shocks
 - will worsen the hunger and food security indicators
 - Can reduce or increase the stress on land and water resources
- Lower food waste and loss:
 - Can offset the damage from environmental stressors on land and water resources

https://mygeohub.org/groups/glass

Group: GLASS

mygeohub.org/groups/glass

powered by MyGeohub

LOGIN REGISTER

NEWS RESOURCES COMMUNITY EVENTS AFFILIATED PROJECTS ABOUT US

 **PURDUE UNIVERSITY GLASS**
Global to Local Analysis of Systems Sustainability

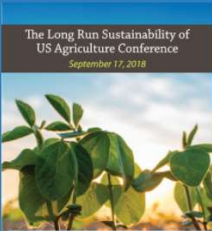
Meeting the Global Sustainable Development Goals on a Changing Planet with Limited Land and Water Resources
[Getting started](#)

RESEARCH HIGHLIGHTS

Employing Global-to-Local Analysis of Systems Sustainability Approach



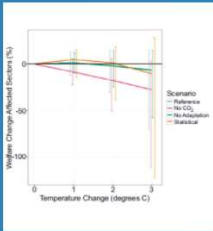
A Digital Model for Globally Sustainable Agriculture - Tackle global sustainability challenges by building a digital, global, gridded model of agriculture and hydrology that accounts for markets and trade, as well as external forcings such as population and income growth and climate change.



The Long Run Sustainability of US Agriculture - understand and communicate the interplay between global change and local sustainability of US agriculture
September 17, 2018



An interesting study that combines SIMPLE-G-Corn-Soy and a power-system model to show the linkage between biomass co-firing, land use and water quality in the Midwest.



Impacts of climate change on crop yields and economic welfare: meta-analysis of process-based and statistical models